REGRESSION MODEL OF WATER RESOURCES MANAGEMENT OF DISTRIBUTED IRRIGATION SYSTEMS

A.A.Aydarova, Sh.S.Axralov, A.A.Abduvaitov, J.J.Jumanov

https://doi.org/10.5281/zenodo.7219620

Abstract*. This article presents a regression model of water resources management of distributed irrigation systems. In addition, a software product for the implementation of this model has been developed. Based on the created program, the results were obtained and analyzed.*

Keywords*: water resources, regression, statistics model, optimal management, packet program, water network structure, channel system.*

РЕГРЕССИОННАЯ МОДЕЛЬ УПРАВЛЕНИЯ ВОДНЫМИ РЕСУРСАМИ РАСПРЕДЕЛЕННЫХ ОРОСИТЕЛЬНЫХ СИСТЕМ

Аннотация. *В данной статье представлена регрессионная модель управления водными ресурсами распределенных оросительных систем. Кроме того, разработан программный продукт для реализации данной модели. На основе созданной программы были получены и проанализированы результаты.*

Ключевые слова: *водные ресурсы, регрессия, статистическая модель, оптимальное управление, пакетная программа, структура водной сети, система каналов.*

INTRODUCTION

In the world, special attention is paid to saving water resources and focused on the development of mathematical models, quality criteria for optimal water resources management, necessary conditions for optimality, the development of methods for optimal water resources management of water flow in open distributed channels of irrigation systems, scientific research. In this regard, one of the most important tasks is to improve the mathematical models of water management processes of distributed irrigation systems.

The information structure of the water resources management system for distributed irrigation systems in the middle reaches of the Chirchik River includes: information centers for the management of Parkent, Karasu, Khandam canals, their databases, long-term data on water consumption in canals, hardware and software for canal management, collection technologies, processing and storage of information about the condition of canals, hydraulic structures, water intakes, water nodes, etc.

MATERIALS AND METHODS

For the study, data were obtained on the water discharge in the Parkent, Karasu and Khandam canals in the period from 2010 to 2020. When calculating patterns using the regression method, 3959 rows of tabular data were taken into account.

The average air temperature was calculated 3956 times. The average minimum temperature in the territories where the Parkent, Karasu and Khandam canals flow was -17 degrees Celsius, the maximum average temperature was +31 degrees. The mean value was 10.493 degrees, and the standard deviation from the norm was 9.678. The temperature values for all three studied channels are the same, since the temperature was calculated in the Tashkent region [1].

RESULTS

In the Karasu canal, the minimum water consumption per day in 2010 - 2020 was 1.477 million cubic meters, the maximum - 3.948 million cubic meters. Standard deviation 0.837.

Fig. 1.

Discharge regression in the Karasu channel.

Goodness of fit statistics	Karasu expenditure
Observations	3956
Sum of weights	3956
DF	3954
R^2	0,985
Adjusted R^2	0,985
MSE	0,011
RMSE	0,103
MAPE	3,733
DW	0,566
Cp	2,000
AIC	-18019,842
SBC	-18007,276
PC	0,015

R^2 - the coefficient of determination is 0.985. This means that the model has an accuracy of 98.5%, which means it is well suited to describe the process. In other words, the information on water consumption is explained by 98.5% of the air temperature.

Another important part of the output is the odds table. It was used to determine the following model of water flow in the Karasu canal:

$$Q = 1{,}01624580953268E\text{-}02 + 8{,}58467611727509E\text{-}02 * T_{avg}$$

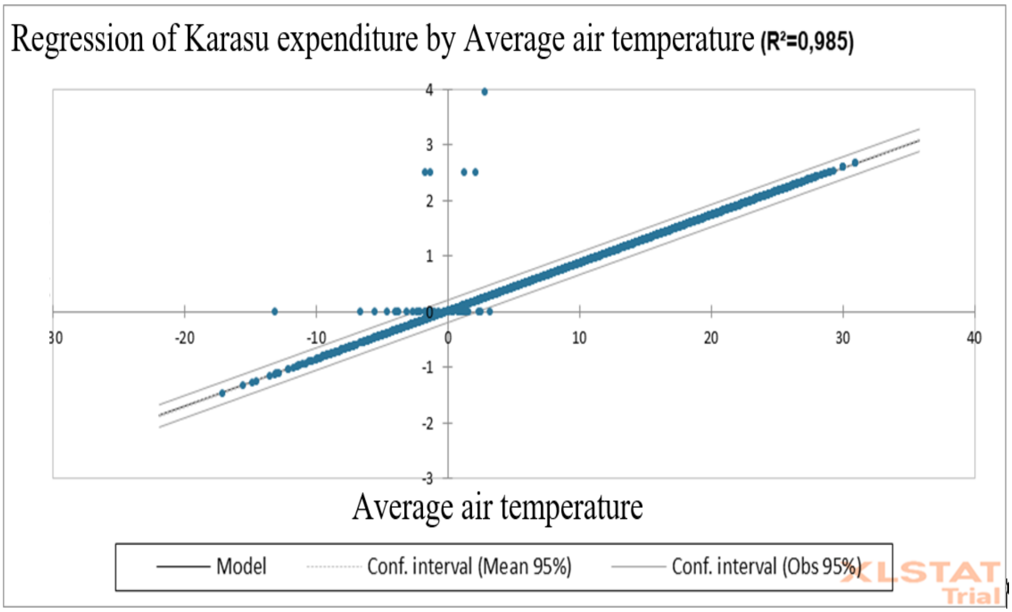
where Q – canal water consumption in one day,

T_{avg} – average air temperature.

The regression graph of the water flow rate in the Karasu canal and the average air temperature is shown in the figure below 2.

Fig. 2.

Regression of water discharge in the Karasu canal.



Regression of Karasu expenditure by Average air temperature

In the Parkent Canal, the minimum water consumption per day in 2010 - 2020 was 1.477 million cubic meters, the maximum - 2.678 million cubic meters. Standard deviation 0.833.

R^2 - the coefficient of determination is 0.997. This means that the model has an accuracy of 99.7%, which means it is well suited to describe the process. In other words, the information on water consumption is explained by 99.7% of the air temperature.

Another important part of the output is the odds table. It was used to determine the following model of the water flow rate in the Parkent Canal:

$Q = 6{,}41692685131978E\text{-}03 + 8{,}59722593239059E\text{-}02 * T_{avg}$

where Q – canal water consumption in one day,

T_{avg} – average air temperature.

The regression graph of the water flow rate in the Parkent canal and the average air temperature is shown in the figure below 4.

Fig. 3.

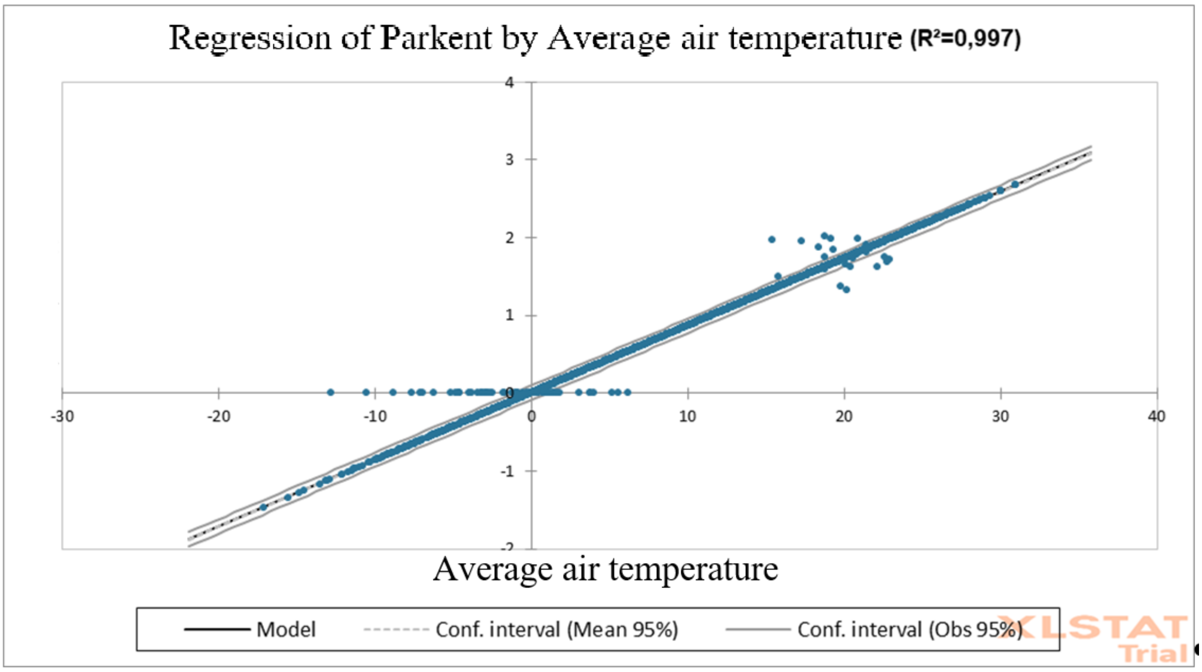
Regression of water discharge in the Parkent Channel.

Goodness of fit statistics Parkent expenditure

Observations	3956
Sum of weights	3956
DF	3954
R^2	0,997
Adjusted R^2	0,997
MSE	0,002
RMSE	0,047
MAPE	2,306
DW	0,441
Cp	2,000
AIC	-24231,773
SBC	-24219,207
PC	0,003

Fig. 4.

Regression of water discharge in the Parkent Channel.



In the Khandam canal, the minimum water consumption per day in 2010 - 2020 was 1.477 million cubic meters, the maximum - 2.678 million cubic meters. Standard deviation 0.836.

Fig. 5.

Regression of water discharge in the Khandam channel.

Khandam expenditure

Goodness of fit statistics

Observations	3956
Sum of weights	3956
DF	3954
R^2	1,000
Adjusted R^2	1,000
MSE	0,000
RMSE	0,000
MAPE	0,000
DW	
Cp	
AIC	
SBC	
PC	0,000

R^2 - the coefficient of determination is 1. This means that the model has an accuracy of 100%, that is, it is well suited for describing the process. In other words, the information about the water consumption is 100% attributable to the air temperature.

Another important part of the output is the odds table. It was used to determine the following model of water flow in the Handam canal:

$Q = 8{,}63999999999999E\text{-}02 * T_{avg}$

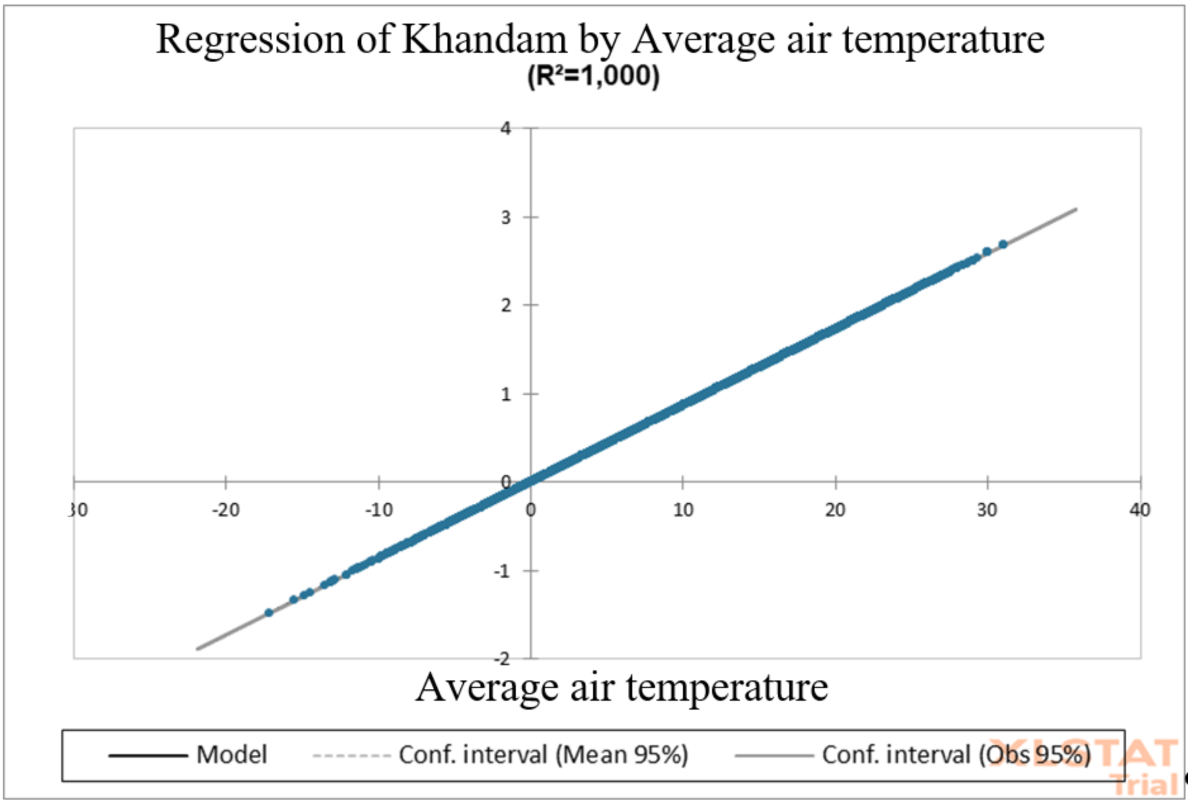
where Q – canal water consumption in one day,

T_{avg} – average air temperature.

The regression graph of the water flow rate in the Parkent canal and the average air temperature is shown in the figure below 6.

Fig. 6.

Regression of water discharge in the Khandam channel.



As can be seen from Figure 6, the line is straight, which corresponds to 100% correctness of the linear regression model.

The table below shows information on the average annual water discharge in the Karasu, Parkent, Handam canals for the last 10 years.

When developing a software package for solving the problem of modeling water resources management processes in the middle reaches of the Chirchik River, the c # programming language was used. Programming was carried out in the Visual Studio environment. Data science and analytical applications workload and R Tools for Visual Studio (RTVS) were used for data analysis.

Parameters of the Karasu channel used as input in the program: Q_0=260 м^3/c; H_0 = 6,77 м; g = 9,8м/c^2; y = 1/6; l = 25 км; i = 0,00005; B_0 = 68,4м; υ_0 = 0,94м/c; КПД = 25, where Q_0 – water flow in the canal section; H_0 – depth of water flow in this section of the canal; b_0 – width of water flow at the bottom of the free area of the canal; g– gravitational constant; l - channel section length; i_i– channel bottom slope; υ_0 – water flow rate; ω_0 – free area of the water flow in the channel [2].

Table 1.

Average annual water consumption in Karasu, Parkent, Handam in 2011-2020.

Years	Average temperature	Karasu Average water consumption, mln m^3/s	Parkent Average water consumption, mln m^3/s	Handam Average water consumption, mln m^3/s
2011	16,375	134,76235	30,42	13,466
2012	16,5416	112,415045	34,81	22,92

2013	17,666	134,66155	37,35	20,742
2014	15,4166	153,57744	27,835	18,558
2015	17,666	129,517	28,7834	21,3228
2016	18,5833	163,73	34,077	21,8124
2017	13,333	149,49	40,95	22,3056
2018	16,9166	156,73	32,326	20,78
2019	17,2916	91,55	133,329	63,864
2020	19,25	144,35	24,3	22,21

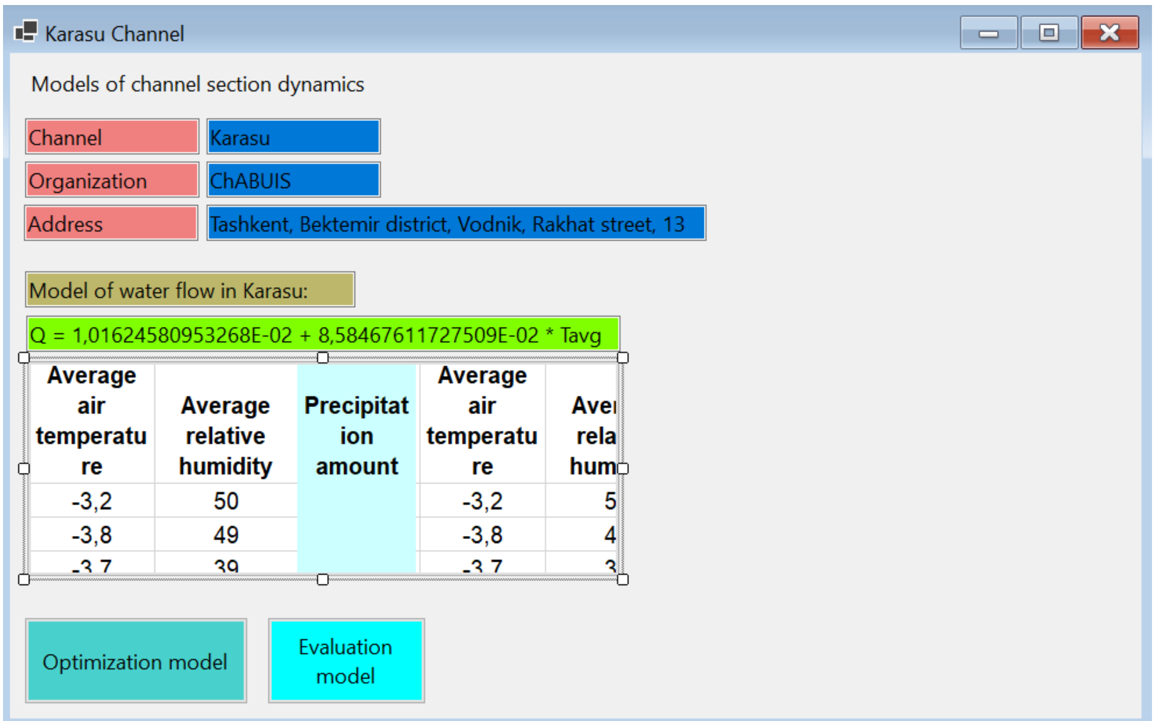
DISCUSSION

When programming the tool for implementing the algorithm on the Karasu channel, the following result was obtained:

It can be seen from the figure that, after opening the gates, the increased flow rate at the beginning of the canal section makes it possible to increase the water level along the length of the specified section in the Karasu canal. During t = 13 445 s (22.4 min.), The water level at the end of the section increases by 1.7 m [3]. Parkent channel parameters: $Q_0 = 57$ м^3/с; $H_0 = 2{,}69$ м; g = 9,8м/с^2; y=1/6; $l = 5{,}5$ км; $i = 0{,}00005$; $B_0 = 64$ м; $\upsilon_0 = 0{,}86$ м/с; КПД = 25, where Q_0 – water flow in the canal section;

Fig. 7.

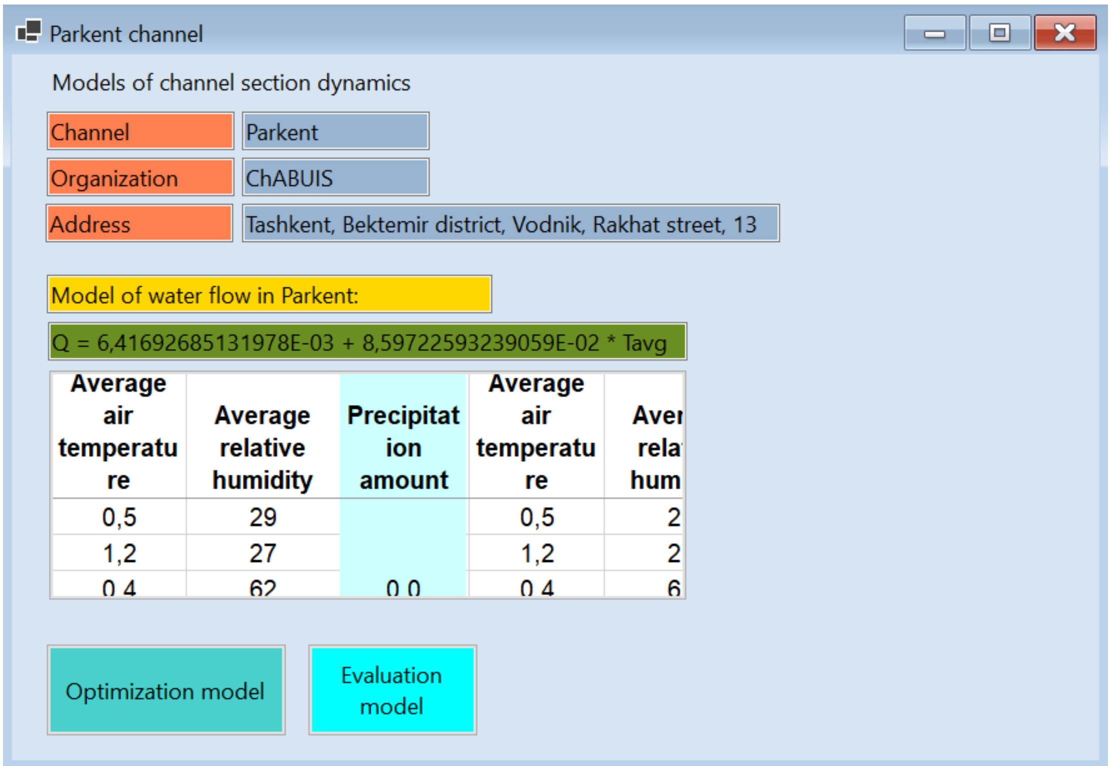
Calculation result. Karasu Channel.



H_0 – depth of water flow in this section of the canal; b_0 – width of water flow at the bottom of the free area of the canal; g– gravitational constant; l - channel section length; i_i– channel bottom slope; υ_0 – water flow rate; ω_0 – free area of the water flow in the channel.

Fig. 8.

Calculation result. Parkent Canal.

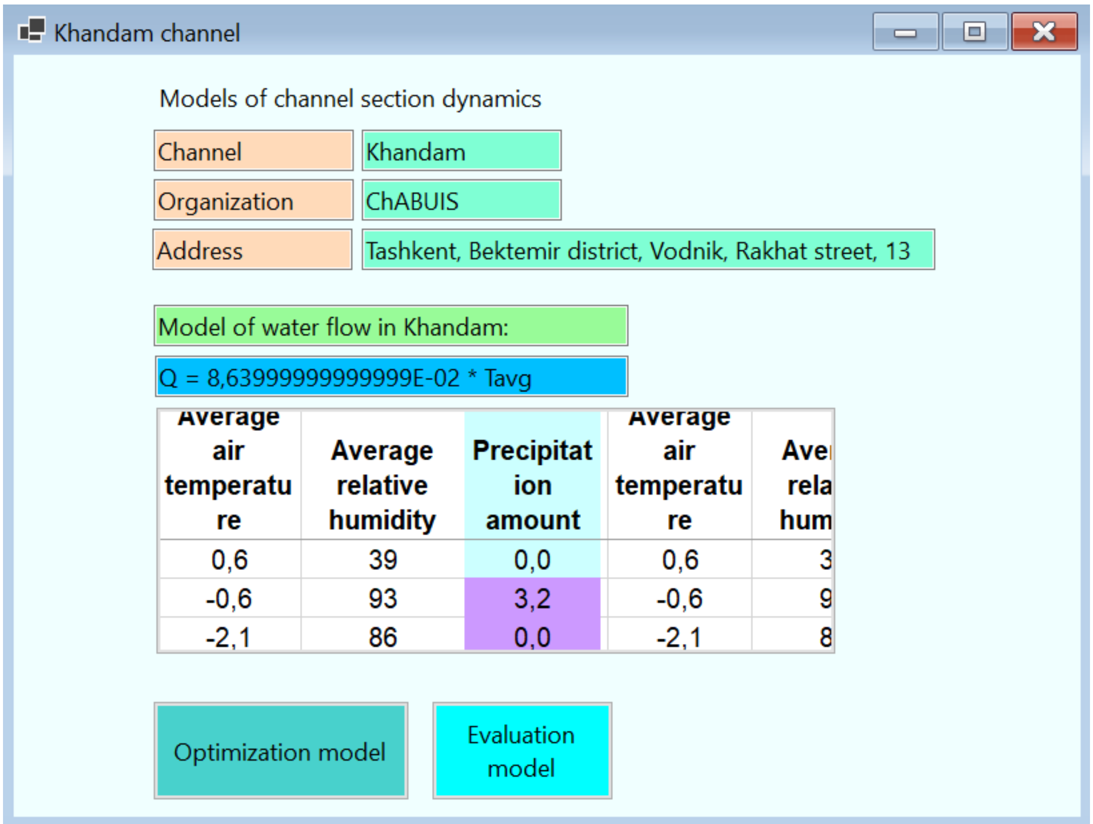


It can be seen from the figure that, after opening the gates, the increased flow rate at the beginning of the canal section makes it possible to increase the water level along the length of the specified Parkent canal section. During t = 13 445 s (22.4 min.), The water level at the end of the section increases by 1.6 m [4].

Handam channel parameters: Q_0=30 м^3/с; H_0= 2,69 м; g = 9,8м/с^2; y =1/5; l = 5км; i = 0,00005; B_0 = 68 м; υ_0 = 0,86 м/с; КПД = 25, where Q_0 – water flow in the canal section; H_0 – depth of water flow in this section of the canal; b_0 – width of water flow at the bottom of the free area of the canal; g– gravitational constant; l - channel section length; i_i– channel bottom slope; υ_0 – water flow rate; ω_0 – free area of the water flow in the channel.

Fig. 9.

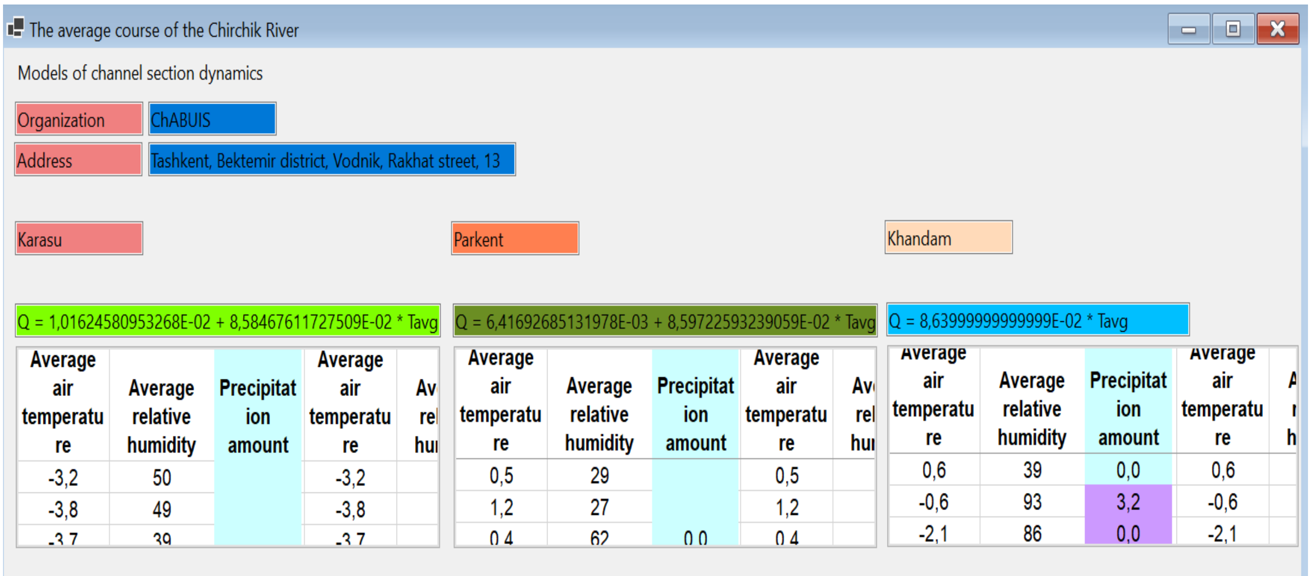
Calculation result. Canal Handam.



It can be seen from the figure that, after opening the gates, the increased flow rate at the beginning of the canal section makes it possible to increase the water level along the length of the specified section of the YuMMC. During t = 13 445 s (22.4 min.) The water level at the end of the section increases by 1.5 m.

Fig. 10.

The result of calculations for the middle course of the Chirchik River.



CONCLUSIONS

The obtained calculation results show that the water level and flow rate at the end of the canal section is stabilized, which is necessary for the water intake from the canal located there.

Comparison of the results of numerical experiments and field studies carried out in the selected sections of the Karasu, Parkent and Handam canals show that the parameters of the flow rate and water level in them differ insignificantly, their error is no more than 5-7%.

This confirms that the algorithm developed within the framework of this study is efficient and can be applied to control the distribution of water in the sections of various gravity canals of irrigation systems.

REFERENCES.

1. A.Aydarova. Modeling of water resources management processes. AgriRev2020: The Digital Agricultural Revolution: Innovations and Challenges in Agriculture through Technology Disruptions. EasyChair. Publication: by Wiley-Scrivener, USA.
2. A.Aydarova. Water resources management models. VII International Scientific and Practical Conference "SCIENTIFIC HORIZON IN THE CONTEXT OF SOCIAL CRISES". 6-8 February 2021 г. Tokio, Japan.
3. A.Aydarova. Conditions for optimal water resources management. Academic research in educational sciences. Ares.uz Volume 1. issue 3. 2020 ISSN: 2181-1385. Scientific Journal Impact Factor (SJIF) 2020: 4.804. p. 234-239.
4. A.Aydarova. Mathematical models of water resources management for irrigation systems. Journal of Engineering Science. 2020 (September). https://scholar.google.com/scholar?cluster=17806354188467910768&hl=en&oi=scholarr
5. J.Kh.Djumanov, I.Khabibullayev, S.Khushvaqtov, U.Mardiev. Improvement of groundwater monitoring on the basis of modern info-communication and GIS technologies/ International Conference on Information Science and Communications Technologies: Applications, Trends and Opportunities, ICISCT Tashkent.2021
6. S.S.Akhralov, R.A.Yusupov, H.S.Egamberdiev, J.J.Jumanov Geoinformation technologies and methods of mathematical modeling in hydrogeological research InterCarto, InterGIS, 2020, 26, стр. 240–252
7. J.Kh.Djumanov, A.Abduvaitov Monitoring of Groundwater Status Based on Geoinformation Systems and Technologies International Conference on Information Science and Communications Technologies: Applications, Trends and Opportunities, ICISCT 2021, 2021
8. J.Djumanov, R.Yakhshibaev, S.Khushvaktov, N.Sayfullaeva Mathematical model and software package for calculating the balance of information flow International Conference on Information Science and Communications Technologies: Applications, Trends and Opportunities, ICISCT 2021, 2021
9. S.Kodirov, J.Djumanov. Intra-annual surface runoff distribution of the Chatkal River in different watery years/ E3S Web of Conferences, 2021, 264, 01035
10. J.Kh.Djumanov, I.Khabibullayev, S.Khushvaqtov, A.Mirsoatov, E.A.Anorboev, F.A.Mamirov. Application geoinformational technologies in hydrogeological research/ International Conference on Information Science and Communications Technologies: Applications, Trends and Opportunities, ICISCT 2021, 2021

Information about authors

A.A.Aydarova -researcher Computer injiniring faculty of the Tashkent University Information Technologies named after Muhammad al-Khwarizmi

Sh.S.Axralov -researcher Computer injiniring faculty of the Tashkent University Information Technologies named after Muhammad al-Khwarizmi

A.A.Abduvaitov -head of Information resource Center of the Samarkand branch at Tashkent University Information Technologies named after Muhammad al-Khwarizmi

J.J.Jumanov-magistrate Geological faculty of the Tashkent Sate Technical University named after Islom Karimov